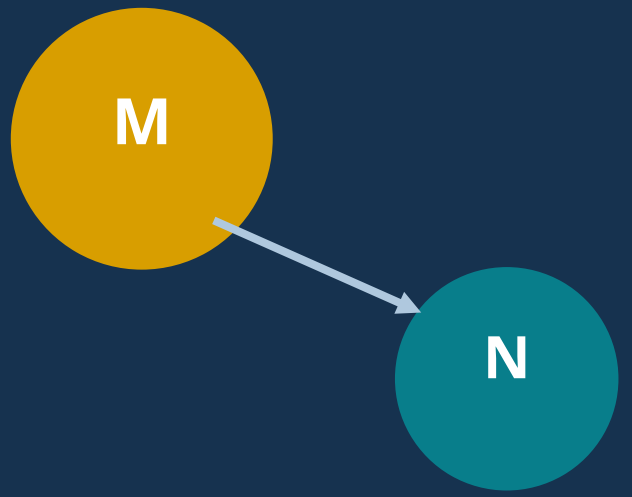
# METALS & NON-METALS

Class X Science • Chapter 3




Teaching deck
with diagrams • exceptions • reactions • exam prompts

# Learning map

What students should be able to explain by the end of the chapter

# 1. Physical properties of metals

Start with observable properties before moving to chemical behaviour

### Lustrous

Freshly polished metal surfaces are generally shiny (metallic lustre).

### Malleable

Can be beaten into thin sheets. Gold and silver are especially malleable.

### Ductile

Can be drawn into thin wires. Gold is the most ductile metal.

### Sonorous

Many metals produce a ringing sound when struck.

### Heat conductors

Metals generally conduct heat well; silver and copper are among the best.

### Electrical conductors

Metals generally allow electric current to pass through.

### Hardness

Metals are generally hard, but hardness varies between metals.

### TEACHER NOTE

Ask: Which property explains a copper wire? Which explains a sheet of aluminium?

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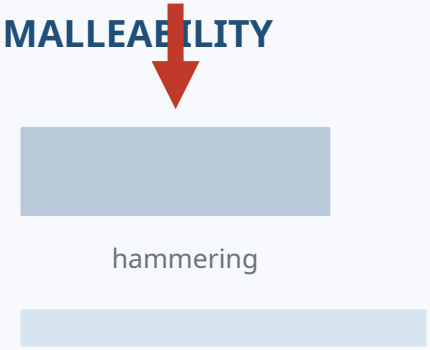
# Property “simulations” for the classroom

Use these as visual explanations before/after a live demo

### MALLEABILITY



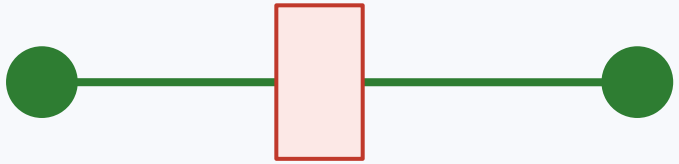
hammering

→ thinner sheet

### DUCTILITY

→ thin wire

### ELECTRICAL CONDUCTIVITY



bulb ON

## Teacher link

Ask students to identify the property used in wires, cooking utensils, bells and foil.

## Safety

Sodium handling and burning-metal demonstrations require teacher assistance and appropriate precautions.

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# 2. Non-metals: the pattern and the exceptions

Do not teach the table as an absolute rule

## Typical non-metal pattern

Dull • brittle • non-malleable • non-ductile • poor conductors • generally lower melting points than many metals.

## Important exceptions

Iodine is lustrous. Graphite conducts electricity. Bromine is liquid at room temperature.

## Big idea

Physical properties alone cannot cleanly classify every element. Chemical behaviour gives a clearer basis for classification.

## TEACHER NOTE

Exam trap: “All non-metals are poor conductors” is not universally true — graphite is the textbook exception.

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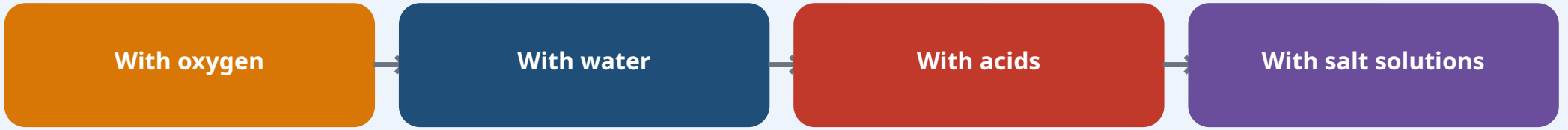
# Chemical properties of metals

Now move from “what metals look like” to “how metals react”



# 3. Metals + oxygen → metal oxides

Reaction intensity depends on the metal

**Metal + Oxygen → Metal oxide**

| | | | | | |
|---|---|---|---|---|---|
| **Na** Sodium | **Mg** Magnesium | **Al** Aluminium | **Fe** Iron | **Cu** Copper | **Ag** Silver |
| very vigorous | vigorous on burning | protective oxide layer | filings burn readily | black CuO on heating | no reaction with $O_2$ |

### Example

$2Cu + O_2 \rightarrow 2CuO$ (black copper(II) oxide)

### Protective layers

Al, Zn, Pb and Mg can form oxide layers that slow further oxidation.

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# 4. Amphoteric oxides

Some metal oxides react with both acids and bases

### Basic oxides

Most metal oxides are basic in nature.

### Amphoteric

$Al_2O_3$ and ZnO show both acidic and basic behaviour.

### Aluminium oxide

Reacts with acids AND bases to form salt + water / aluminate.

$$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$$

### TEACHER NOTE

Word to emphasise: “amphoteric” = both acidic and basic behaviour.

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# 5. Metals + water

Build a reaction map instead of memorising isolated cases

**Very reactive** → **Moderate / special** → **No reaction**

### K, Na

React violently with cold water. Hydrogen can catch fire because the reaction is strongly exothermic.

### Ca, Mg

Ca reacts with cold water less violently. Mg reacts with hot water; $H_2$ bubbles can make it float.

### Al, Fe, Zn / Pb, Cu, Ag, Au

Al, Fe and Zn react with steam. Pb, Cu, Ag and Au do not react with water.

**Metal + Water → Metal oxide + $H_2$ (then oxide + water → hydroxide, where applicable)**

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# 6. Water reactions: visual simulation

Compare what students would observe

| | | | | |
|---|---|---|---|---|
| **K / Na** | cold water | violent + heat | $H_2$ catches fire | HIGH |
| **Ca** | cold water | bubbles + floats | $H_2$ evolves | HIGH |
| **Mg** | hot water | bubbles + floats | $H_2$ evolves | MED |
| **Al / Fe / Zn** | steam | metal oxide + $H_2$ | needs steam | LOW |
| **Pb / Cu / Ag / Au** | water | no visible reaction | least reactive | LOW |

**Teacher prompt**

Why does calcium float after reacting? → hydrogen bubbles stick to its surface.

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# 7. Metals + dilute acids

Typical pattern: salt + hydrogen

**Metal + Dilute acid → Salt + $H_2$**

## Relative reactivity observed in the chapter

Mg > Al > Zn > Fe > Cu (with dilute HCl)

## Observation clues

More bubbles + higher temperature → faster / more exothermic reaction. Copper shows no bubbles with dilute HCl.

**$Mg + 2HCl \rightarrow MgCl_2 + H_2$**

**$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$**

## TEACHER NOTE

Important exception: $HNO_3$ usually does not release $H_2$ because nitric acid is a strong oxidising agent; very dilute $HNO_3$ is an exception for Mg and Mn.

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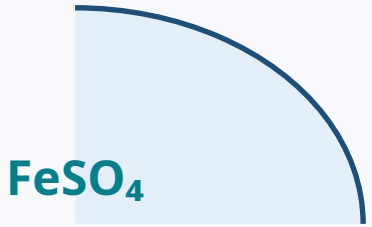
# 8. Metals + salt solutions = displacement

A more reactive metal displaces a less reactive metal

**Metal A + Salt solution of B → Salt solution of A + Metal B**




Cu wire

**Fe nail → brown Cu deposit**

## Conclusion

Fe is more reactive than Cu because iron displaces copper from $CuSO_4$. This provides strong evidence for the reactivity series.

## Reaction type

Displacement reaction.

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# 9. The reactivity series

Memorise the order by meaning, not just by letters

**Most reactive**

| | |
|---|---|
| **K** | Potassium |
| **Na** | Sodium |
| **Ca** | Calcium |
| **Mg** | Magnesium |
| **Al** | Aluminium |
| **Zn** | Zinc |
| **Fe** | Iron |
| **Pb** | Lead |
| **H** | Hydrogen |
| **Cu** | Copper |
| **Hg** | Mercury |
| **Ag** | Silver |
| **Au** | Gold |

**Least reactive**

## Use the series to predict

- metal + water
- metal + acid
- displacement
- extraction method

## TEACHER NOTE

Hydrogen is shown as a reference point, not a metal.

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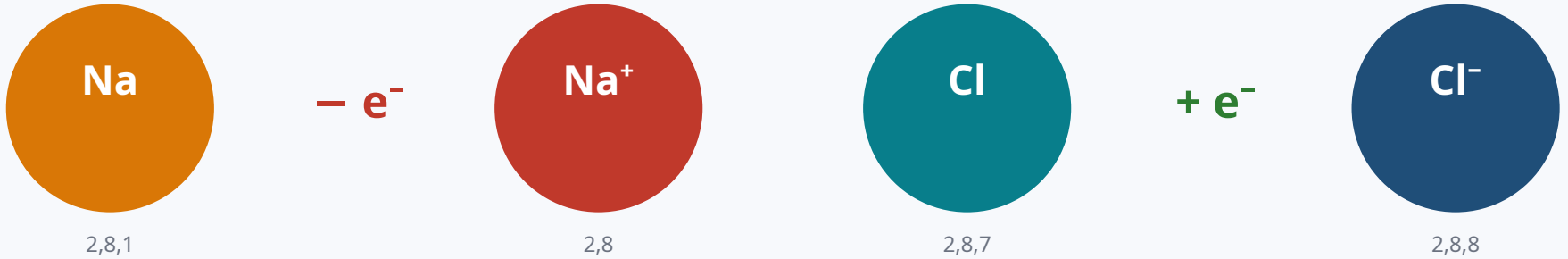
# 10. Why metals react: electron transfer

Connect the reactivity series to electronic configuration




$$Na^+ + Cl^- \rightarrow NaCl$$

## Core idea

Atoms tend to reach a stable filled outer shell. Metals commonly lose electrons; non-metals commonly gain electrons.

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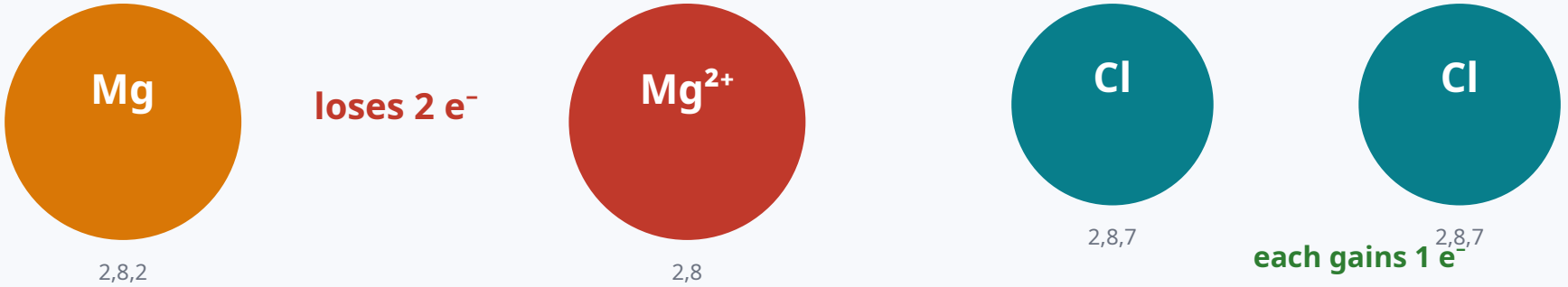
# 11. Formation of magnesium chloride

One metal transfers two electrons




$$Mg^{2+} + 2Cl^{-} \rightarrow MgCl_2$$

### Ionic compound

Compounds formed by electron transfer from a metal to a non-metal are ionic (electrovalent) compounds.

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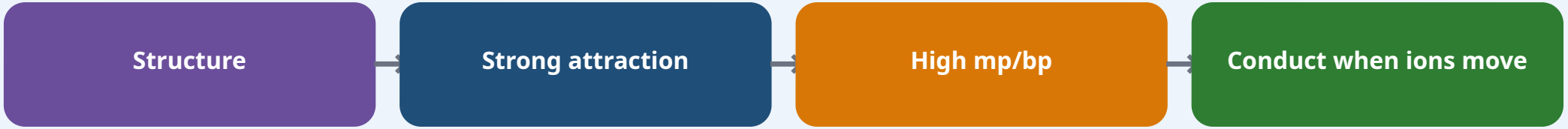
# Ionic compounds

From electron transfer to observable properties



# 12. Properties of ionic compounds

Explain each property using the particle model

### Physical state

Generally solids; strong attraction between oppositely charged ions.

### Melting & boiling

High melting and boiling points because strong inter-ionic attraction must be overcome.

### Solubility

Generally soluble in water and insoluble in kerosene/petrol.

### Electrical conduction

Solid: ions are fixed → no conduction. Molten / aqueous: ions can move → conduction.

solid: fixed ions

solution: moving ions

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# 13. Occurrence of metals: mineral vs ore

Where metallurgy begins

### Mineral

Naturally occurring elements or compounds found in the earth’s crust.

### Ore

A mineral containing a sufficiently high percentage of a metal for profitable extraction.

### Gangue

Unwanted impurities such as soil and sand mixed with the ore.

### Reactivity connection

Low-reactivity metals may occur in the free state; highly reactive metals are found combined in compounds.

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# 14. Extraction map from the activity series

The position of a metal decides the broad extraction strategy

### High reactivity

K, Na, Ca, Mg, Al
→ very strong affinity for oxygen
→ electrolytic reduction

### Middle reactivity

Zn, Fe, Pb, Cu
→ convert sulphides/carbonates to oxides
→ reduce oxide (often with carbon)

### Low reactivity

Cu, Ag, Au (and others near bottom)
→ often found native or extracted by heating/reduction

### TEACHER NOTE

Do not teach “one method for every metal”: extraction route follows reactivity.

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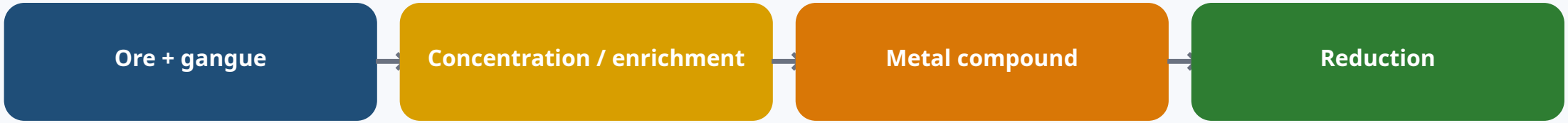
# 15. Enrichment of ores

First remove gangue — then extract the metal




## Why enrich?

Ores are usually mixed with large amounts of soil, sand and other impurities. Separation uses differences in physical / chemical properties.

## Teacher link

Ask students why “ore” is not the same as “pure metal”. Emphasise economic extraction.

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# 16. Low-reactivity metals

Heating may be enough to obtain the metal

$$2HgS + 3O_2 \rightarrow 2HgO + 2SO_2$$

$$2HgO \rightarrow 2Hg + O_2 \text{ (on heating)}$$

### Cinnabar example

HgS is the ore of mercury. It is heated in air to form HgO; further heating gives mercury.

### Copper example

Copper sulphide ores can also be converted to copper by heating in air through a sequence of reactions.

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# 17. Middle-reactivity metals: roasting vs calcination

Two ore-conversion routes

## ROASTING

Sulphide ore + excess air + heat → metal oxide + gas

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

## CALCINATION

Carbonate ore + limited air + heat → metal oxide + $CO_2$

$$ZnCO_3 \rightarrow ZnO + CO_2$$

### Memory cue

Roasting → sulphides; Calcination → carbonates.

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# 18. Reduction of metal oxides

Metal oxide → metal

$$ZnO + C \rightarrow Zn + CO$$

### Carbon reduction

Suitable for several metals in the middle of the activity series.

### Displacement reduction

Highly reactive metals such as Al can reduce oxides of less reactive metals.

### Thermit reaction

$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3 + heat$

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# 19. Thermit reaction

A dramatic example of displacement + redox

$$Fe_2O_3 + 2Al \rightarrow 2Fe(l) + Al_2O_3 + Heat$$

## Why it works

Al is more reactive than Fe and has a strong affinity for oxygen. It removes oxygen from $Fe_2O_3$.

## Application in chapter

Used to join railway tracks or repair cracked machine parts.

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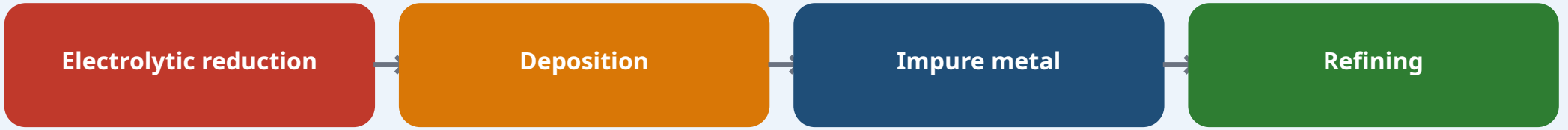
# Extraction → refining

High-reactivity metals require electrolysis; extracted metals are then purified



# 20. High-reactivity metals: electrolytic reduction

Carbon cannot reduce oxides of K, Na, Ca, Mg and Al

### Reason

These metals have a greater affinity for oxygen than carbon. So carbon reduction is not suitable.

### Alternative

Electrolysis of molten compounds gives the metal at the cathode. Example: molten chlorides of Na, Mg and Ca.

**Cathode: $Na^+ + e^- \rightarrow Na$**

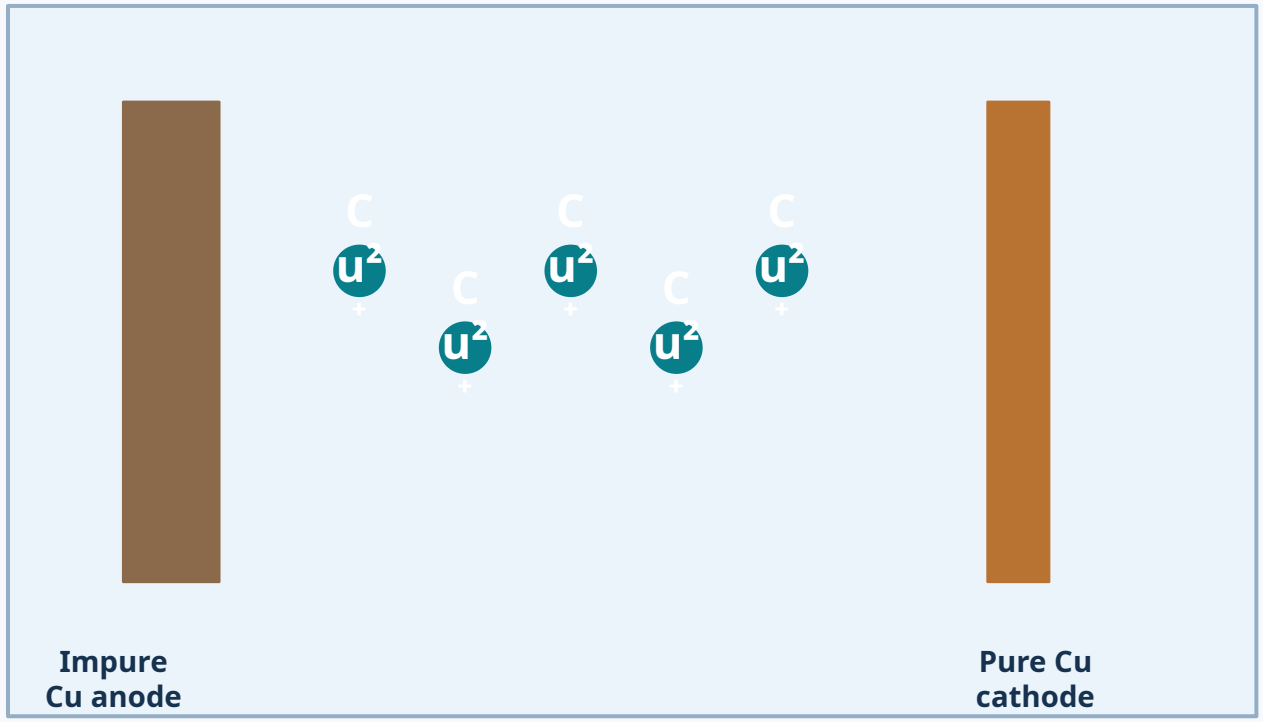
**Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$**

### Key vocabulary

Cathode = negative electrode in the electrolysis setup shown here; anode = positive electrode.

# 21. Electrolytic refining of copper

Impure anode → pure cathode




## Electrolyte

Acidified copper sulphate solution.

## Anode mud

Insoluble impurities settle at the bottom.

## Result

Pure copper deposits on the cathode.

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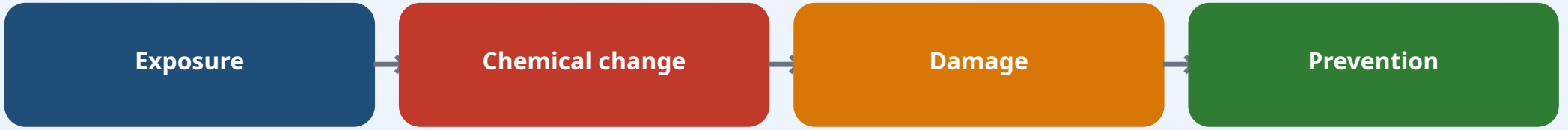
# Corrosion & protection

Connect chemistry to everyday materials



# 22. Rusting: both air and water are needed

A simple controlled-investigation model

**A** water + air

rusts

**B** boiled water + oil

no rust

**C** dry air

no rust

## Conclusion

Rusting needs access to both air and water (moist conditions). Remove either condition and rusting is prevented in this experiment.

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# 23. Corrosion examples beyond iron

Different metals form different surface products

### Silver

Turns black because it reacts with sulphur in air to form silver sulphide.

### Copper

Develops a green coating of basic copper carbonate in moist air.

### Iron

Acquires a brown, flaky coating called rust in moist air.

### Everyday link

Tarnished copper vessels can be cleaned using lemon/tamarind juice because acidic substances help remove the surface deposits.

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# 24. Preventing corrosion

Barrier + material choice + alloying

### Painting

blocks air/water

### Oiling / greasing

blocks moisture

### Galvanising

zinc coating

### Chrome plating

protective finish

### Anodising

thicker $Al_2O_3$ layer

### Alloying

changes properties

### Galvanisation insight

A zinc coating can protect steel/iron even when the coating is scratched, because zinc is more reactive and helps protect the iron.

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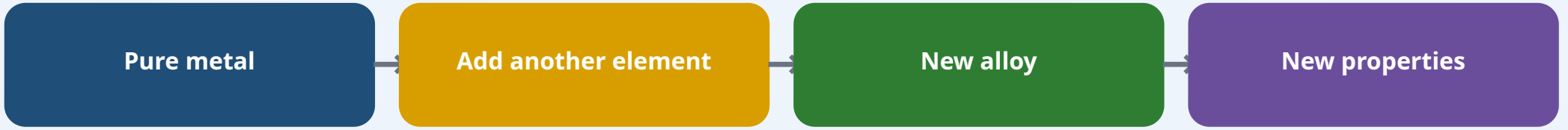
# Alloys & applications

Modify properties to make materials fit the job



# 25. Alloys: changing properties on purpose

An alloy is a homogeneous mixture of two or more metals, or a metal and a non-metal

### Brass

Copper + zinc
Used where harder / useful mechanical properties are needed.

### Bronze

Copper + tin
An important traditional copper alloy.

### Solder

Lead + tin
Low melting point; used for joining electrical wires.

### Gold jewellery

Pure 24-carat gold is very soft. 22-carat gold in the chapter uses 22 parts gold + 2 parts silver or copper.

### Steel & stainless steel

Pure iron is soft. Adding carbon makes it harder/stronger. Nickel + chromium gives stainless steel, which resists rust better.

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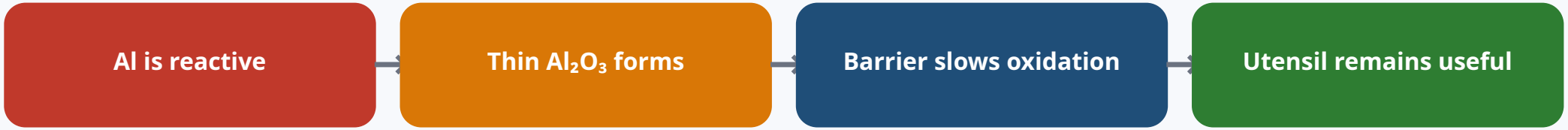
# 26. Why aluminium utensils work despite high reactivity

A classic “apparent contradiction”




## Oxide layer

Aluminium develops a thin oxide layer in air. The oxide coat protects the metal from further corrosion.

## Anodising

The protective oxide layer can be made thicker by anodising and can be dyed for an attractive finish.

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# 27. The “exceptions” slide — must remember

Use this slide as a retrieval practice checkpoint

### Liquid metal

Mercury — Metal, but liquid at room temperature

### Low-melting metals

Gallium, caesium — Can melt in your palm

### Lustrous non-metal

Iodine — Shiny despite being a non-metal

### Conducting non-metal

Graphite — Carbon allotrope that conducts electricity

### Very soft metals

Li, Na, K — Can be cut with a knife

### Amphoteric oxides

$Al_2O_3$, ZnO — React with acids and bases

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# 28. Chapter-at-a-glance concept map

Use this for the final 5-minute recap

### Properties

lustre
malleability
ductility
conductivity

### Reactions

$O_2$ • $H_2O$
acids
salt solutions

### Ions

lose $e^-$
gain $e^-$
ionic bonds

### Extraction

ore → oxide
reduction
electrolysis

### Protection

rusting
prevention
alloys

### Big principle

Reactivity links electron behaviour → reactions → extraction method → material use.

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# 29. Exam focus: predict before you calculate

Use the reactivity series as a decision tool

### Q1: Can displacement occur?

Compare the free metal with the metal ion in solution. More reactive metal wins.

### Q2: Will acid give $H_2$?

Check whether the metal is above hydrogen in the reactivity series; remember the nitric-acid exception.

### Q3: How is it extracted?

Top of series → electrolysis. Middle → oxide + reduction. Bottom → often easier / native.

$$Zn + FeSO_4 \rightarrow ZnSO_4 + Fe$$

### Answer key

Yes — Zn is above Fe, so zinc displaces iron.

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# 30. Rapid-fire classroom check

Pause and let students answer before revealing the right idea

| | |
|---|---|
| **1. Why is Na kept under kerosene?** | To limit contact with air/water because it is highly reactive. |
| **2. Why does graphite conduct?** | Graphite is a non-metal allotrope of carbon but conducts electricity. |
| **3. What is an amphoteric oxide?** | An oxide that reacts with both acids and bases. |
| **4. What does a displacement reaction tell us?** | It can establish which metal is more reactive. |
| **5. What conditions rust iron?** | Exposure to both air and water / moisture. |

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# 31. NCERT exercise spotlight

Selected questions to use for guided practice

## Multiple choice

- Which pair gives displacement?
- Best method to prevent rusting of an iron pan?
- Why are food cans coated with tin instead of zinc?

## Short answers

- Define mineral / ore / gangue.
- Why do ionic compounds have high melting points?
- Give examples of amphoteric oxides.

## Reasoning

- Aluminium is highly reactive yet used for cooking utensils.
- Carbonate and sulphide ores are converted to oxides.

## Application

- How would you distinguish metals and non-metals with a simple circuit?
- Why are Cu hot-water tanks preferred over steel?

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# Metals & Non-metals

The five ideas to remember

1. Properties have patterns — and exceptions.
2. Reactivity follows electron behaviour.
3. Reactivity series predicts reactions.
4. Extraction method depends on reactivity.
5. Corrosion & alloys connect chemistry to real materials.

Suggested closing task: “Choose one metal and explain its properties, reactions, extraction and protection using the chapter.”